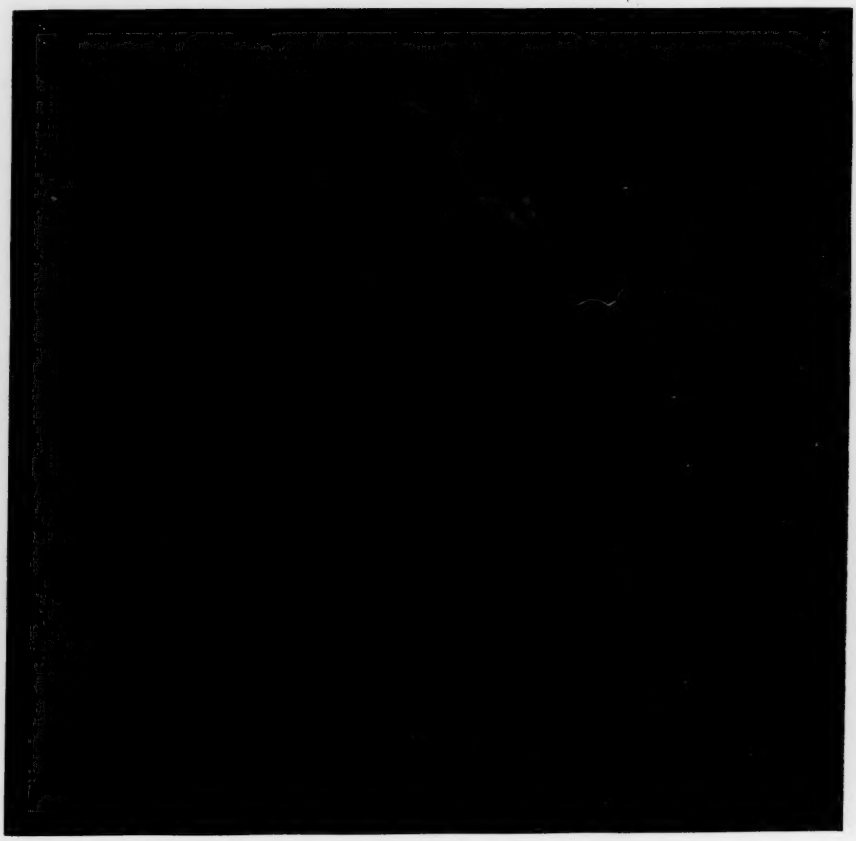
The Journal of HEREDITY



SUSCEPTIBLE *vs* APHID-PROOF SEEDLINGS
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Pattern Reversal in Hybrid Plumage

Family Allowances in Canada

Polyallel Crosses in Cattle

VOLUME 36 DECEMBER, 1945 NUMBER 12

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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The JOURNAL OF HEREDITY is published monthly by the AMERICAN GENETIC ASSOCIATION at 32nd Street and Elm Avenue, Baltimore, Md., and 1507 M St., N. W., Washington, D. C. Address all communications regarding editorial matters to 1507 M. St., N. W., Washington, D. C. Communications regarding the business management of THE JOURNAL OF HEREDITY may be addressed to the publication office, 32nd Street and Elm Avenue, Baltimore, Md., or to 1507 M St., N. W., Washington 5, D. C. Entered as second-class matter February 24, 1923, at the postoffice at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in section 1103, Act of October 3, 1917, authorized December 29, 1918.

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The
Journal of Heredity

Vol. XXXVI DECEMBER, 1945 No. 12

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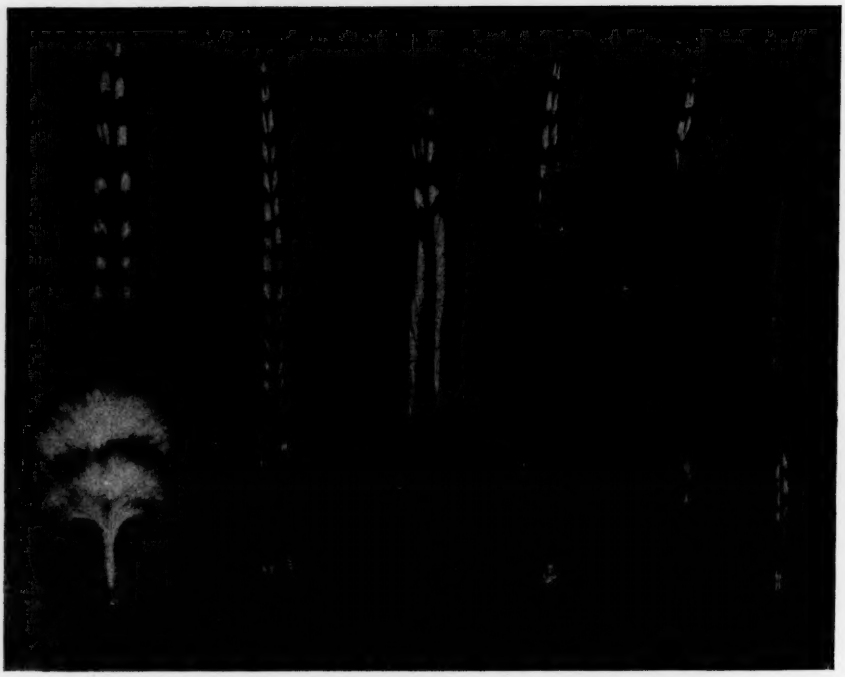

PATTERN REVERSAL THROUGH METABOLIC CHANGE

Figure 1

Normal and thiouracil-modified saddle feathers from No. 652, F_1 ♂, from a Barred Rock ♂ × Brown Leghorn ♀ mating. *A*—Normal black and white barring. *B*—Thiouracil-modified barring. *C*—Normal Leghorn-like feather with barring appearing only at the feather apex. *D* and *E*—Leghorn-like feathers with normal apices but showing thiouracil-modified structural changes in the basal sections together with the induced appearance of barring at this new level. *F*—Entirely thiouracil-modified feather showing a complete reversal of pattern: the apex being Leghorn-like and the base black and white barred.

PATTERN REVERSAL IN THE PLUMAGE OF THIOURACIL-TREATED HYBRID FOWL*

MARY JUHN

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THE F_1 male descendants from matings between black-and-white barred fowl and parti-colored red and black fowl are barred for the greater part of the plumage but sporadic feathers may resemble the other parent over their entire length, or, most frequently in their basal sections only, the tips being barred. These so-called exceptional feathers have attracted a good deal of attention; they have been reported to possess identical pattern in successive generations by Hertwig and Rittershaus[3] and by Kuhn[6] and they have been interpreted as originating in the loss of part of the X-chromosome,[3] and by Serebrovsky,[8] in the loss of one sex chromosome carrying the factor for barring.

The present author[4] however found that serially replacing feathers from individually identified follicles in F_1 males of Barred Rock × Brown Leghorn crosses showed no correspondence of pattern. She advanced the hypothesis that the potentialities for barring and Leghorn plumage were continually present in the hybrid and that the appearance of one or the other pattern derived from the interaction between the respective genetic factor with a variable morphogenetic factor such as the rate of growth. If this interpretation be correct, the determination of plumage pattern should prove amenable to agents acting through the cytoplasm.

In this laboratory, hybrids of several breeds of fowl are being studied for range of plumage modification. Among the substances used in these tests is thiouracil† added as five grams per kilo of dry feed and selected because of its known effect in diminishing the secretory activity of the thyroid with the resulting depression of metabolic level (Astwood, et al.,[1] MacKenzie and MacKenzie[7]).

The feathers described were collected June 29, 1945, from young males hatched July 18, 1944 and placed on a thiouracil diet January 23, 1945. The experimental birds continue under observation and treatment in order that the full extent of possible reactions may be established.

Included in this series are F_1 males of the same Barred Rock × Brown Leghorn cross referred to earlier in this paper; the reaction in their feathering to thiouracil is described here. The structural feather changes, elongation, narrowing, and reduction in barbulation found when the drug was administered to the Brown Leghorn (Juhn,[5] Domm and Blivaiss[2]) also became manifest here (compare Figure 1*A* and *B*), together with certain significant changes which developed in the patterns of the treated Leghorn-like feathers. When barring is present in the normal Leghorn-like feathers of this hybrid it is at the apex only, Figure 1*C* (earlier observations and present data). In such feathers which had developed a normal apical section but which showed a characteristic thiouracil structure in the basal portion, it was found that barring reappeared at this foreign location in association with the thiouracil modification (Figure 1*D, E*). Figure 1 *F* shows an entirely modified feather with a Leghorn-like apex and a barred base, a complete reversal of the pattern normally encountered. These results show clearly that a depression of metabolic level such as is here caused by thiouracil may directly affect phenotypic expression and

*Scientific paper No. A109, Contribution No. 1986, of the Maryland Agricultural Experiment Station (Department of Poultry Husbandry).

†The thiouracil used was obtained through the kindness of Dr. Mark Welsh, Lederle Laboratories, Inc.

they substantiate the interpretation originally advanced as to the source of pattern distribution in this hybrid feathering.

Summary

The F_1 males from Barred Rock × Brown Leghorn crosses show feathers having barred apices and Leghorn-like bases located among the predominantly barred plumage. Such fowl when placed upon a continuous thiouracil diet show typical structural changes in regenerating fully barred feathers and in addition in the Leghorn-like feathers a complete reversal of pattern, barring appearing in the thiouracil-modified basal section of these feathers.

These observations demonstrate the possibility of an experimental modification of phenotypic expression in the plumage of hybrid fowl through an altered metabolic level caused by thiouracil administration.

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✦

THOMAS HUNT MORGAN

TWO spots stand out as nodal points in the evolution of the study of heredity as an experimental science. A garden in Brunn, in what is now Czechoslovakia, nurtured sundry strains of peas. Crossing them and observing their progeny led Mendel to the discovery of the principle of atomic heredity. In a small room in the city of New York a tall bearded man with an eye for queer fruitflies and gifted students set the stage for the next great step. "For twelve years [1915-1928] we three [Morgan—Sturtevant—Bridges] worked together in a small room in the Zoological department at Columbia University. As work on *Drosophila ampelophila* (as the vinegar fly was then called) became widely known, a succession of international fellows joined us, as well as some of the more advanced graduate students and fellows of Columbia University. It was not unusual for six of us to carry on in this small room; the only space at our disposal. Those were the days when bananas were used as fly food and in one corner of this room a bunch of bananas was generally on hand—an adjunct of our researches which interested other members of the laboratory in a different way. As there were no incubators a bookcase and a wall case were rigged up with electric bulbs and a cheap thermostat that behaved badly at times, with consequent loss of cultures. . . . This picture of the conditions under which we worked is not intended to suggest that we were handicapped. On the contrary our proximity to each other led to cooperation in everything that went on. . . . I doubt whether the modern students with all their equipment and assistance get as much joy out of their work as we had with our primitive setup."

Some of the other faculty members were a little scandalized at the bottle-cluttered room redolent of rotting bananas. But the theory of the gene came out of that room, and the demonstrations that in the end left no doubt that the chromosomes were the actual carriers of heredity. Years later the quiet man with the twinkling eyes was awarded the Nobel Prize for the products that came from his strange menagery.

Dr. Morgan died on December 4 at Pasadena, busy in his laboratory until very near the end. His passing will be mourned as a personal loss by those who follow the path he blazed to make the study of heredity an exact science.

A SEEDLING METHOD FOR TESTING APHID RESISTANCE

And Its Application to Breeding and Inheritance Studies in Cucurbits and other Plants

S. S. IVANOFF

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IN breeding cantaloupes for resistance to aphids (*Aphis gossypii* Glover), a quick and accurate method has been devised for testing resistance which is applicable to other cucurbits and perhaps to cotton and other crops. Since resistance to aphids seems closely associated genetically with resistance to downy mildew (*Peronoplasmopara cubensis* B. and C., Clinton) in inbred lines of certain West Indian muskmelons,[2] the technique is also applicable to the selection of cantaloupes resistant to this disease. The advantages of this method over the field method, which depends on natural infestation, are: speed, economy, a high degree of accuracy, dependability, and simplicity. It can be employed at any time of the year in the greenhouse, or out-of-doors, when the danger of frost is over. The method and its application to breeding and inheritance studies are described in this article for the benefit of plant breeders interested in developing varietal resistance to aphids in these and possibly other crops.

The method is based on the fact that if aphids are placed on the emerging first true leaf of a susceptible plant in a very short time the leaf petiole bends downward and the young leaf begins to curl. Such effects are not produced on resistant plants.

The details of the method as applied to cantaloupes are as follows: The seed is planted rather thickly, one inch or less apart, in a bench or in flats. As soon as the first true leaf is about three millimeters in length, the seedlings are covered with aphid-infested cucurbit leaves. The aphids crawl from these leaves to the seedlings and in about 30 minutes to one hour all of the seedlings, resistant and susceptible, become thoroughly infested. The aphids are to be found all over the plants but particularly on the underside of the cotyledons which may be covered with them. Susceptible plants under ordinary conditions begin to react to the infestation in about 24 hours. In less than 48 hours after infestation, all susceptible plants show at first a bent petiole, and then a small curled leaf. In contrast to this all resistant plants, although thoroughly infested, remain unchanged in these respects as shown in Figures 2 and 3. As a standard procedure, the final records can be taken 48 hours after the aphids have been applied and the test completed. This period is somewhat variable since the plant reaction depends on the rate of growth of the plant. Under optimum conditions for the growth of cantaloupes, the entire operation from planting the seed to taking the final records usually takes eight to ten days. When the plants were grown unseasonably in the winter at low temperatures, the test required a correspondingly longer period for completion, but the reliability of the test was unimpaired. If left in place, susceptible plants usually die, while resistant plants become in time free or almost free from aphids when given good growing conditions. The insects persist longest on the first true leaf of resistant plants but cause no curling.

The minimum number of aphids necessary to induce bending the petiole and curling of the leaf of susceptible plants has not been determined but observations suggest that only a few aphids may be sufficient. However, to insure uniformity of infestation and avoid possibility of

escapes, an abundance of aphids on each plant is desirable.

The time for applying the aphids to the plant is important for quickest and most accurate results. When the aphids are applied earlier than mentioned, curling is delayed because the presence of the insects seems to slow the emergence of the primary leaf. When the aphids are applied some time after the emergence of the primary leaf, curling may likewise be delayed and the reaction of the susceptible plants may not be uniform. Exact standardization of the testing technique is not always necessary, but it is particularly desirable if slight differences in susceptibility are to be detected.

Efficiency and Adaptability of the Method

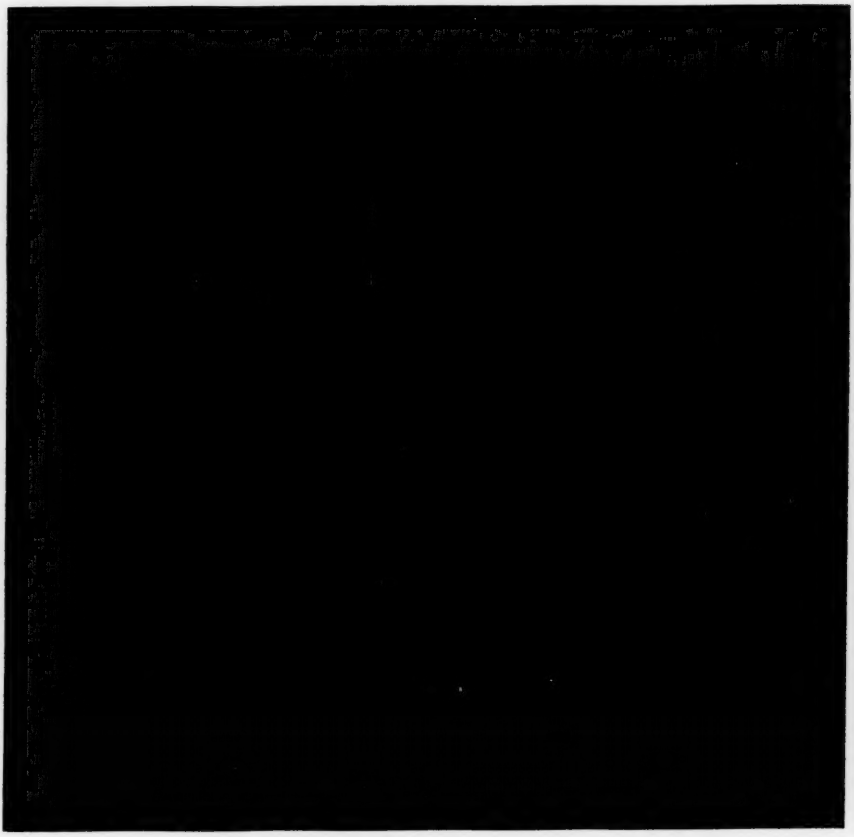
It was highly important to determine whether the absence of curling of the primary leaf in the seedling stage is a reliable indication of resistance under severe natural infestation in the field. The method would not be applicable with any degree of confidence in detecting resistance in individual plants belonging to small segregating populations unless its reliability is comparable to or exceeds that of the field method of testing under severe natural infestation. To establish this point several different types of cantaloupe plant material, both resistant and susceptible, were tested by the two methods.

Nine susceptible commercial varieties were tested by the quick method. Each variety was tested from 1 to 9 times with a total of 588 plants. All plants in all the trials showed bending of the petiole and curling of the primary leaf in less than 48 hours. It was noted that some varieties curled their leaves more severely than others, indicating slight differences in varietal susceptibility. Such slight differences in varietal susceptibility have been noted in the field also. Several hundred plants of the aphid-resistant varieties of West Indian muskmelons were tested and a large number of inbred lines derived from these varieties as well as the new aphid

SEGREGATING PROGENY

Figure 2

A second hybrid generation (F_2) group of seedling cantaloupes of a cross between a susceptible and a resistant variety. Three days before the photograph was taken the seedlings were artificially infested with aphids. The susceptible plants are marked with X's. The aphids remain for a time on the resistant plants but do not affect their growth and eventually these plants become aphid free. By this method of seedling testing it is possible to differentiate the susceptible plants at an early stage of growth.



CLOSE-UP OF SUSCEPTIBLE AND RESISTANT PLANTS

Figure 3

Shortly after the emergence of the first true leaf, three days before this photograph was taken, these two seedlings were infested with aphids. Many aphids can be seen on the lower surface of the leaf of the resistant plant at the right, but the leaf and petioles are still erect. This quick and reliable test for aphid resistance can be used on all of the cucurbits, and preliminary tests indicate it is effective with some other plants as well.

and downy mildew resistant variety, Texas Resistant Cantaloupe No. 1.[3] In no case did the primary leaf of any plant show any sign of curling.

Plants of F_1 crosses between resistant and susceptible parents did not show signs of susceptibility when tested in the seedling stage by the method described. Neither did they suffer appreciably when tested under natural field infestation.

Plants of the second generation of several resistant and susceptible crosses when tested either in the seedling stage or under natural conditions in the field showed about the same ratio between resistant and susceptible plants by either method. There were three trials by the quick method with artificial infestations, one trial in the greenhouse with natural infestation, and one trial in the field under natural conditions of severe aphid occurrence. In the latter trial, where

the plants were normally spaced, all susceptible plants were stunted at maturity and their leaves were curled with a large number of aphids, while the resistant plants were aphid-free or with only a trace of aphids with no curling of the leaves. In all these trials of F_2 populations the ratio between resistant and susceptible plants was 3:1 (Table I).

The method was employed in testing the progenies of F_3 and subsequent generations for the rapid separation of the resistant from the susceptible plants in the mixed populations. Similar applications of the method may be found the most useful to the plant breeder, since the elimination of susceptible lines or the selection of individual resistant plants may be accomplished in a very short time, soon after the seed are harvested.

Resistant plants selected by this method, and transplanted to the field, have remained either entirely free or practically free from aphids with no curling of the leaves, while susceptible plants, grown side by side, have suffered severe damage and have produced hardly any fruit. In seasons of very severe aphid occurrence in the field, however, when susceptible plants were killed outright, slight curling occurred occasionally on terminal leaves of a few resistant plants in a large planting but the infestation was of insignificant economic importance and the application of insecticides was not necessary. Likewise, when some resistant plants were grown under unfavorable environmental conditions, such as under shade near trees and the vines appeared dwarfed for lack of nutrients and water, several terminal leaves curled and the plants suffered some aphid damage before they finally recovered.

The method was used in isolating downy mildew resistant plants on the basis of their resistance to aphids, in material derived from some West Indian muskmelons, in which, as already mentioned, the resistance to the two parasites is closely associated. There are other downy mildew resistant muskmelons, however, introduced by the U. S. Department of Agriculture from India which have shown no appreciable resistance to aphids. Evidently this method cannot be applied to populations derived from this material. Likewise, the two downy mildew resistant commercial cucumbers, Puerto Rico 39, and Burpee Hybrid 160 have not shown appreciable resistance to aphids.

Other Species of Cucurbits Tested For Aphid Resistance

Insofar as the writer is aware there are no commercial aphid-resistant varieties of cucumber, watermelon, or squash in this country. Should this method prove effective for testing these plants, it may possibly be employed in discovering sources of resistance in material of recent foreign origin. The results of the tests are as follows:

Cucumbers reacted in the same way as cantaloupes when the quick method was applied to them. However, as was expected, no resistance as to aphids was found among the several hundred plants of the common commercial varieties tried, including A and C, Burpee's Hybrid 160 (an F_1 hybrid, resistant but not immune to downy mildew, mosaic, and bacterial wilt[4]), Ohio 31, and Puerto Rico 39 (downy mildew resistant). As with the cantaloupes, some of these varieties exhibited different degrees of varietal susceptibility as shown by the degree of leaf curling. None of these varieties, however, can withstand a severe or even a moderate aphid infestation in the field without the application of insecticides.

With watermelons, the method seems as applicable as with cantaloupes and cucumbers.

Squash plants react somewhat more slowly than cantaloupes, cucumbers, and watermelons. The curling of the primary leaves is only slight. Unlike the other cucurbits, this species seldom, if ever, curls its leaves when heavily infested with aphids under field conditions. Squash plants in the field alongside susceptible cantaloupes, cucumbers, and watermelons, suffered considerably less aphid damage than the other cucurbits.

The tests with squash seem to offer additional proof of the accuracy of the method in determining various degrees of resistance.

Tests with Cotton and other Crops

Dunnam[1] found that pilosity (hairiness) of the cotton leaves had a relation to *A. gossypii* infestation. He compared aphid population, percentage of parasitization, and number of leaves infested on glabrous and pilose varieties of cotton under field conditions. He found that the pilose cotton had more aphids than the glabrous cotton.

Following Dunnam's findings the writer tested two varieties of cotton,* Stoneville 2B (hairy), and Mebane Estate (smooth). Two tests were made at two different times in an outdoor bench, with a total of 66 plants. The aphids, obtained from cucumbers and watermelons, were applied as soon as the primary leaves reached about three millimeters in size. Curling of the leaves was slower than in the case with the cucurbits. Hence the final records were taken about a week after infestation.

The results of the two trials showed that the hairy leaf variety on the average had 83 per cent of the plants with curled leaves while the smooth leaf variety had 11 per cent. Two other plantings of the same variety were made and the plants were allowed to become infested naturally. The hairy leaf variety had on the average 77 per cent of the plants with curled leaves, while the smooth leaf variety had 48 per cent. It is noteworthy that in all tests the reaction to the aphids in the two varieties was not as uniform as with the cucurbits, since some plants had their leaves more severely curled than others and there were some plants in both varieties which did not show curled leaves. Whether this lack of uniformity in curling should be attributed to the inadequacy of the technique as applied to cotton or to the genetic diversity of the cotton in regard to aphid resistance is not clear. The test should be made with lines of cotton homozygous for resistance or susceptibility if available.

Emerging leaves of okra seedlings of the susceptible variety Clemson Spineless were uniformly curled.

In view of the results obtained, it is possible that this method for testing resistance may be adapted to other plant species and with other aphids which cause curling of the young leaves. It has already been tried with the bean aphid on Brabham cowpeas with satisfactory results.

Summary

A practical and rapid method is described for testing resistance to aphids (*Aphis gossypii* Glover) in cucurbits by artificial infestation in the seedling stage. The advantage of this method over the field method which depends on natural infestation are: speed, economy, high degree of accuracy, dependability, and simplicity.

The method is also useful for isolating lines resistant to downy mildew (caused by *Peronoplasmopara cubensis* B. and C., Clinton) in certain cantaloupes where resistance to aphids is closely associated genetically with resistance to this disease. The method is applicable to cotton and okra and may be adaptable to other species.

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Table I. Comparison of the artificial (A.I.) and natural (N.I.) methods of aphid infestation in determining the ratio between resistant and susceptible plants in F_2 populations derived from F_1 crosses between homozygous resistant and homozygous susceptible lines. (Trials made at various times from 1943 to 1944).

Method employed for determining resistant and susceptible plants	Location	Total number of plants under test 1/	Susceptible plants		Ratio* resistant: susceptible plants
			Number	Percent	
Artificial infestation					
Seedling plants	Greenhouse	189	48	25.39	2.93 : 1
" "	Outdoor bench	124	39	31.36	2.27 : 1
" "	" "	314	79	25.09	3.15 : 1
Natural infestation					
2-week old plants	Greenhouse	100	25	25.00	2.84 : 1
8-week old plants	Field	161	39	24.22	3.13 : 1
Totals and weighted averages		888	217	24.43	3.09 : 1

1/ In each trial there were sufficient numbers of known susceptible and resistant plants to serve as checks. All check plants behaved for resistance as expected.

*The writer wishes to acknowledge the courtesy of Mr. D. T. Killough of the Division of Agronomy, Texas Agr. Exp. Station, for supplying seed of these two varieties.

FAMILY ALLOWANCES IN CANADA

THE Dominion of Canada has just embarked on a revolutionary social welfare experiment with very important eugenic implications. During July the first monthly checks were mailed to families entitled to payment under the Family Allowance Act, which will distribute nearly a quarter of a billion dollars a year to some 1,350,000 Canadian families, whose annual income is less than three thousand dollars. At present some thirty countries have a wide variety of family allowance plans in operation. This Canadian experiment is among the most liberal of these, with an outlay involving a larger proportion of the federal budget than any other country.

Graded Payments

Family allowance payments are not made to children in institutions or to children who are not attending school or receiving equivalent education. They can be withdrawn if the money is not expended exclusively for the benefit of the child. With these exceptions, all the children in the families whose income is less than $1,200 per year receive the full benefits.

Families with income between $1,200 and $3,000 receive partial benefits. The monthly payments are graduated according to age of child and number of children as follows:

Under 6 years	$5.00
6 to 9 years	6.00
10 to 12 years	7.00
13 to 15 years	8.00

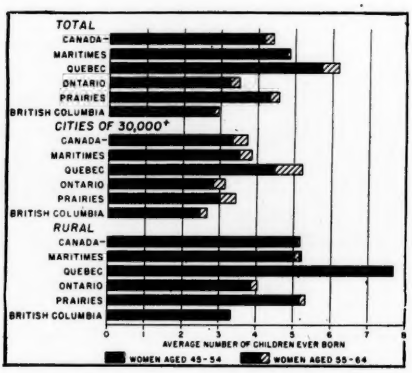
Payments cease when the child reaches its sixteenth birthday. The payments are reduced after a couple have had four children. For the fifth child the above payments are reduced one dollar per month, with a two dollar reduction for six or seven children, and a three dollar reduction for each additional child.

The payments are not supplementary to deductions from income taxes allowed for dependent children. Income taxes for married couples begin at $1,200 per year, and on incomes of $3,000 or more the family allowance benefits are less than income tax deductions. In the bracket between $1,200 and $3,000, partial payments of allowances will be made to offset deductions made from income taxes so that the full amount of the allowance will be paid. The 1941 census reported total population of Canada to be 11,506,655. It is estimated that there are 3½ million children under sixteen years of age. In September, checks totaling $18,317,513 were mailed to 1,345,350 families averaging, according to an official press release, 2.4 children per family. This would represent a total of 3,229,000 children benefitting from the allowances.

If the original estimate of the number of children was approximately correct this means that over nine-tenths of the children in Canada will receive the allowance in full or in part. Aside from agriculture, 57.1% of the families of Canada have an income of less than $1,200 a year. The proportion must be larger among the agricultural population, which has a notably low cash income. This group in Canada, as in other countries, is furnishing a large part of the next generation. Actually less than one-fifth of Canada's families rear more than four-fifths of Canada's children.

Distribution of Benefits

The measure has been under consideration and discussion in Canada since 1929 and the enactment of the law was bitterly argued and violently opposed in certain quarters. One much debated issue was the question of who would be paying for whose children, with rather pointed emphasis on French Canadian Quebec versus the rest of Canada. Actually, the larger Provinces are approximately self-supporting with respect to tax contributions and family allowance benefits. Quebec contributes 34 per cent of taxes, and will receive about 33 per cent of the family allowance funds. Ontario, on the other hand, contributes 47 per cent of taxes and is estimated to receive only 29 per cent of the allow-



BIRTH DIFFERENTIALS IN THE CANADIAN PROVINCES

Figure 4

In completed families, the number of children born to married women in Quebec averages nearly two children more than the total for the rest of Canada. The French Canadian birthrate is at present dropping more rapidly than that of the rest of the population, especially in urban areas. From the *Population Index,* July 1945.

ance funds. The smaller Provinces and the rural areas receive more than they pay. It is the population of these areas rather than French Canada, which receives the greatest benefits.

There are many large families in French Canada, but they do not greatly affect the averages. Among the families who have applied for allowances the average number of children under sixteen is 2.9 for Quebec and 2.4 for Canada as a whole. Only two families in Canada have fifteen children under sixteen years of age receiving family allowances. Six families have fourteen children under sixteen; 44 families have thirteen children and 105 families have twelve children. One-third of one per cent of Canadian families have more than ten children under sixteen, while in Quebec 1.85 per cent have nine or more children. The very high French Canadian birthrate has been dropping more rapidly in recent years than that of the rest of Canada. There are still large differences, however, Quebec's 1940 rate was 25.8 per thousand compared with Ontario's 18.1 per thousand. What effect the family allowance act will have in altering these trends remains to be seen.

Vital Bookkeeping

One unquestionable advance will come out of this experiment. In order to administer the act effectively, Canada has put into operation the most complete and effective scheme of human bookkeeping of any country in the world. To be eligible for the benefits, a child's birth must be properly registered at the Provincial capital. In order to assure that benefit payments are not made to children who have died or left Canada, an interlocking system of vital records has been set up. As the years go by, this system of records will give Canada a more exact and detailed statistical summary of its population, in terms of numbers, and economic status, than any other country. Canada will know with split-hair accuracy, the number of its citizens sixteen years of age and less.

In proportion of the total federal budget, the Canadian family allowance plan appears to be by far the most expensive and the most ambitious in the world. Expenditures of the Canadian federal government were $647,914,429,00 for the year ending March 31, 1944. The September figures give an annual total of $230,690,156 for family allowance for the first year. This represents over 35 per cent of the total budget for the previous year. No specific taxation is provided to furnish these funds. If the major portion of funds are raised through income taxes it means that the fraction of the population reproducing already at far less than replacement rates will be directly assessed to peg the birth rate of the over-producers. The effect of this would seem to be further to unbalance the differential birth rate.

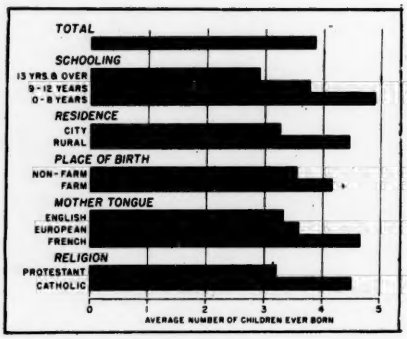
By way of comparison the notably liberal New Zealand plan totals only 12 per cent of the Federal budget, though for a fair comparison a number of other social service benefits found in New Zealand and not in Canada should perhaps be included with the family allowances.

In the Canadian act, the reduction of payments on a graded scale after the fourth child appears to be an expedient to discourage large families and to favor a wider distribution of four- and five-child families. The official explanation is that clothing and supplies used for earlier children can be passed along to later ones. Actually this provision seems to be a clever handicapping technique whereby tax payments by Quebec approximately balance family allowance payments to Quebec.

Early Family Allowance Plans

Family Allowances schemes are wrestling with a problem which is by no means new. The perpetuation of a culture depends on the bearing and rearing of children living in some sort of family organization. Some such mechanism is essential if the social heritage of a human culture is to pass from one generation to the next. Society has an obvious but reluctantly accepted responsibility in maintaining this social organism necessary for its own perpetuation. Especially in an industrial-wage economy there is an inevitable clash between *inequality of need* of families of varying size and *distribution of wages* without relation to this need. Obviously the payment of wages on the basis of the number of children of a worker without regard to the competence of the worker would be wholly unfair and in practice quite unworkable.

Perhaps the oldest plan to circumvent this difficulty was adopted by the Methodist Church in England a century and a half ago. Ministerial stipends were notoriously modest but ministerial families averaged large. This meant that the unmarried or childless minister had a distinct edge on his colleague with a brood of children urgently needing food and clothing. Even were an overly optimistic minister willing to attempt the almost impossible feat of rearing a numerous progeny on an inadequate wage it would be unbearably painful for the communicants of over-familied ministers to watch them and theirs starve in the midst of relative plenty. Obviously something had to be done. This took the form of a fund set up within each church Conference, from which supplementary payments were made to ministers on the basis of the number of their children.

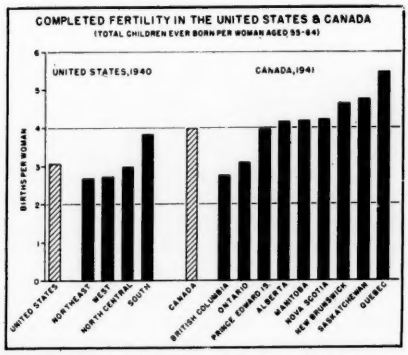


BIRTH DIFFERENTIALS IN CANADA
Figure 5

Data from the 1941 Canadian census figures showing distribution of size of family according to schooling, religion, rural and urban origins, etc. As in all Western countries today, the big population replacements are coming from the underprivileged and the poorly educated. How the redistribution of national income through family allowances will affect these trends remains to be seen. From *Population Index*, July 1945.

At the present time in England these funds pay $40 per year for children under eighteen and $60 per year during the six suceeding more expensive years of college education. In recognizing even inadequately that the financial hump in child rearing usually comes after sixteen, the church is more realistic than most government tax planners who discontinue payments or income tax exemptions about the time the strain on parental resources becomes greatest.

The next important step was made in France. For many years it had been the custom for enlightened French employers to give their workers "liberalities" of indefinite size at times of financial difficulty. These sporadic additions to wages were in effect informal family allowances, but they could not be counted on either as to amount or as to timing. By 1914 this practice had become so general that a number of large firms



UNITED STATE AND CANADIAN REPRODUCTION RATES COMPARED

Figure 6

Only in two Provinces is the Canadian rate lower than in the most fertile U. S. area, the Southern States. Completed families in Quebec average just two more children than the U. S. average. Canada is still a rapidly growing country. From *Population Index,* March 1945.

had adopted a more formal plan. There remained the very real difficulty that individual employers could hardly fail to consider that "liberalities" would be oftener needed by men with families than by bachelors. This would hardly spur workers to risk having large families, and would further depress the already alarmingly low French birthrate.

World War I gave the incentive to the adoption of the "Grenoble Plan," named after the city of its origin, where it was invented by a public spirited manufacturer, Monsieur E. Romanet. It provided for payments by all manufacturers in an industry into an "equalization fund" based on the number of their employees. From this fund payments were made to supplement the wages of all workers having children to support. Since contributions to the fund were based on the number of workers employed, the individual employer had no concern as to the size of his employees' families. Between 1932 and 1936 this plan was adopted on a nationwide basis and in the three succeeding years it was further liberalized and extended.

The Genroble Plan and its later universalization by the French government did not stop further decline in the French birthrate already far below replacement. The symptoms of serious disarrangement in the body politic of France seem to have been too alarming to bring reassurance to married couples, merely by the payment of a few francs a week.

At the present time family allowances, in one form or another, are in operation in some thirty countries. The hysterical birth rate boostings of Mussolini and Hitler, offering bonuses, monthly payments, and lush publicity have followed their sponsors into oblivion. The plans which have survived the war vary in extent, in objectives, and in methods of financing. All too often such plans have attempted to correct a falling birthrate, by encouraging the birth of more babies, no questions asked as to quality.

The Australian family allowance plan differs from all others in paying all parents the same amount regardless of income. This has the merit of recognizing that the babies of the well-to-do may be at least as valuable to society as the babies of those less well off. To extend the Canadian plan to all children would increase the annual budget hardly more than $20,000,000, or ten per cent of the total. This increased expenditure would surely be amply justified biologically if not politically were the birthrate of higher income families appreciably increased as a result.

Cash Versus Other Benefits

In the discussion of the Canadian plan, its proponents argued that payments in cash rather than in goods, services, or family health facilities, was more democratic. This is exactly the opposite of the conclusions of the Swedish Population Commission which blueprinted the most carefully considered and comprehensive plan to raise and equalize the birthrate of an entire nation that has never been undertaken.

The Swedish plan was adopted by the "Mothers and Children's Parliament" of 1937. This represented a deliberate effort to democratize the benefits as much

as possible and to obtain a more equal representation of all classes in the next generation. Instead of cash, universalized benefits were made available, regardless of income, to all Swedish children. In the United States, all children are expected to attend the public schools. In the same way the Swedish plan provides adequate and nutritionally balanced school lunches for all pupils.

Housing was also a problem. With existing facilities badly overcrowded, it was difficult for a family to build a larger house or find larger quarters with the arrival of additional children. Hence, housing was virtually nationalized and the rent paid by growing families was independent of size of house.

Kindergartens, nurseries and other child care services were to be provided so that all mothers could obtain adequate recreation time away from their children, and maternal health and obstetrical care was extended to all citizens. In spite of the fact that the Swedish birthrate had reached such a low point that an actual sharp decline in population was anticipated, the plan included birth control clinics. Information was available to all as a part of the national health program for mothers.

The Population Commission maintained that the only way a democracy could combat a declining birth rate was by constructing a society so soundly that the bearing and rearing of children would be a joy and a privilege rather than a reluctantly assumed duty. A society which must force its members to have children through ignorance or fear or cheap reward lacks the sound motivations which make survival possible.

Prologue or Epitaph?

In formulating the Swedish plan, it was regretfully recognized by the demographic brain-trusters who did the job that no effective political action was possible until the question of *quantity* of population had become crucial. When that point is reached, the qualitative aspects, inescapably basic if the genius of a nation is to be maintained, are an afterthought if they are considered at all. Yet to ignore quality in the biological sense of effective adaptation to environment must always and inevitably lead to deterioration. Until the short-term social objectives of family allowance plans can be achieved in a pattern that protects society from gene erosion, their ultimate effects must be unfortunate.

The unique qualities of mankind set us apart from other organisms, but they do not free us from our biological heritage, nor from the hard fact that evolution is a tight-rope balancing act, not a trip on an escalator. Gene conservation implies selection, either consciously planned or by the hard and impersonal forces of the environment. The day of reckoning can be put off, perhaps, but only for a time. That the time may be too short to justify much optimism was suggested by Dr. Alva Myrdal when she expressed the fear that her history of the Swedish experiment "may come to stand as the epitaph of a society." Destruction of a civilization by gene erosion is less sudden than by atom bombs, but it can be almost as complete.—R. C.

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EVALUATION OF SPECIES CROSSES OF CATTLE BY POLYALLEL CROSSING

A Study of Zebu and Africander × Aberdeen-Angus Cattle Under Subtropical Conditions

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ZEBU cattle have been used extensively in the Coastal Plain area of Texas and Louisiana for crossing with range cattle. This has been done to obtain a hardy, fast-growing type of beef animal that will fatten well in the hot, humid summer climate, characteristic of this area. Zebu cattle originated in India, and are often referred to as Brahman cattle in the United States. They are able to withstand the climate in this region and to utilize pasture satisfactorily. Cattle of European origin do not have the same adaptability to a subtropical climate. Crossing of the two types is done to combine the heat-resistance of the zebu with the desirable carcass qualities of the beef cattle of European origin.

Africander cattle have also been used to a limited extent in the Gulf Coast and adjacent regions. These cattle are indigenous to South Africa, and according to Bosman,[2] may trace to common ancestry with the zebu cattle of India.

The desirability of crosses of both zebu and Africander bulls with Aberdeen-Angus cows has been studied at the Iberia Livestock Experiment Farm, Jeanerette, Louisiana. Some results of these and related studies have been reported by Rhoad and Black.[7] The present paper deals with results of breeding in which several types of bulls were used on the same group of Angus cows. This procedure constitutes an extension of the diallel system of mating, and the term "polyallel" is used in this manuscript to describe it. Diallel crossing was introduced into genetic literature by J. Schmidt[8] and is described by Lush.[4] This report has two objectives: (1) To compare the merits of animals of various types of breeding for use in the Gulf Coast area, and (2) to indicate the possibilities of polyallel crossing as a tool in animal breeding studies.

Weights at birth and six months were used in this study. These were the only objective measures available on all the animals used. The weight at six months is a good measure of the worth of a calf in the Coastal Plain area, since the common practice is to market calves for slaughter at the time they are weaned.

Material and Methods

The data were obtained from a larger study in which matings were not specifically planned to fulfill a polyallel mating scheme. Hence numbers are limited to those females that produced offspring from three or four types of bulls in the course of breeding operations.

Offspring of 28 Angus cows were used in the study. Nine of these cows produced one or more offspring from each of four types of bulls: Angus, zebu, Africander and zebu × Angus. Nineteen cows produced one or more offspring from each of three types of bulls: zebu, Africander and zebu × Angus. The number of Angus cows used is not large, but they came from several different herds in various parts of the country and probably were fairly representative of the breed.

The number of bulls of each type used

*Based on data accumulated at the Bureau of Animal Industry's Iberia Livestock Experiment Farm, Jeanerette, Louisiana. Mr. Rhoad was formerly animal husbandman in charge of that farm. Dr. Phillips is senior animal husbandman in charge of genetics investigations, and Dr. Dawson is associate animal husbandman in the Bureau of Animal Industry, Washington 25, D. C. The authors are indebted to W. H. Black for participation in the planning and execution of the experiments in which the data were obtained.

Table I. Average birth and six-month weights and numbers of all calves from sires of different breeding mated to Angus cows.

Breeding of sire	Identification of sire	Calves at birth 1/ Number	Calves at birth 1/ Weight (lbs.)	Calves at six months 2/ Number	Calves at six months 2/ Weight (lbs.)
Angus	1	5	64.0	5	339.5
	2	9	61.9	9	310.8
	3	6	58.7	6	324.4
	Unknown	2	57.0	1	361.0
	All	22	60.1	15	324.5
Zebu	14	36	76.7	34	397.0
	16	19	80.7	12	399.9
	All	55	78.1	46	397.8
Africander	1	11	66.4	8	384.9
	2	33	72.1	31	393.4
	All	44	70.8	39	392.5
Zebu x Angus	7	14	68.0	15	371.5
	45	1	76.6	1	467.2
	51	19	77.6	17	400.8
	68	3	69.3	3	349.7
	151	5	69.1	5	388.0
	All	42	72.8	39	388.0
Total and average		168	72.5	141	381.8

1/ Weights of female calves adjusted to male basis. Means for individual sires within the breeds do not differ significantly, except in the Zebu x Angus group where offspring of sires 7 and 51 differ significantly. For significance of differences between group averages, see table V.

2/ Weights of female calves were corrected to male basis. Means for individual sires do not differ significantly within the breeds, except for the two Africander sires.

Table II. Analysis of variance of birth weights of calves out of nine Angus cows mated to Angus, Zebu, Zebu x Angus, and Africander bulls.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total, using unweighted means	35	2998.9	
Between means of breed of sire	3	1619.2	539.7**
Between means of dams	8	510.2	63.8
Interactions	24	888.9	34.5
Experimental error 1/	80		41.0
Total, using weights of individual calves	68	8734.2	
Between breed of sire, dam subclasses	35	4897.4	141.1**
Within breed of sire, dam subclasses	30	1796.8	59.9
Between sires within breed of sire and dam subclasses	15	972.1	67.8
Within sires within breed of sire and dam subclasses	19	982.7	54.3

1/ The experimental error, 41.0, equals 59.9 divided by the harmonic mean (1.459) of the subclasses within breed of sire and within dams.

** Highly significant, P = < .01

Table III. Analysis of variance of birth weights of calves out of nineteen Angus cows mated to Zebu, Zebu x Angus and Africander bulls.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total, using unweighted means	56	5082.9	
Between means of breed of sire	2	311.3	155.6 *
Between means of dams	18	1641.8	90.1 *
Interaction	36	1149.8	31.9
Experimental error 1/	60		45.7
Total, using weights of individual calves	116	10684.8	
Between breed of sire, dam subclasses	56	6811.9	118.7 *
Within breed of sire, dam subclasses	60	4518.9	71.9
Between sires within breed of sire and dam subclasses	29	1821.7	62.8
Within sires within breed of sire and dam subclasses	31	2491.2	80.4

1/ The experimental error, 45.7, equals 71.9 divided by the harmonic mean (1.645) of the subclasses within breed of sire and within dams.

* Significant, P = < .05

Table IV. Average birth weights of calves from nine Angus cows mated to Angus, Zebu, Africander and Zebu x Angus bulls, and differences between the groups of calves.

Breeding of sire	Average birth weight (pounds)	Differences: Angus	Zebu	Africander
Angus	60.2	—	—	—
Zebu	78.1	18.0 **	—	—
Africander	70.5	11.2 **	7.6 *	—
Zebu x Angus	66.7	9.4 **	9.4	1.8

* Significant, P = < .05 ** Highly significant, P = < .01

Table V. Average birth weights of calves from nineteen Angus cows mated to Zebu, Africander and Zebu x Angus bulls, and differences between the groups of calves.

Breeding of sire	Average birth weight (pounds)	Differences: Zebu	Africander
Zebu	76.9	—	—
Africander	72.3	4.6 *	—
Zebu x Angus	71.7	5.2	0.6

*Significant, P = < .05.

Table VI. Analysis of variance of six-month weights of calves out of nine Angus cows mated to Angus, Zebu and Africander bulls.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total, using unweighted means	26	29870.9	
Between means of breed of sire	2	20292.4	10146.2 *
Between means of dams	8	8187.7	1081.0
Interactions	16	10410.8	650.7
Experimental error 1/	18		1498.1
Total, using weights of individual calves	44	94297.2	
Between breed of sire, dam subclasses	26	54997.0	2192.2
Within breed of sire, dam subclasses	18	37040.1	2057.8
Between sires within breed of sire and dam subclasses	6	4845.1	807.5
Within sires within breed of sire and dam subclasses	12	32195.0	2682.9

1/ The experimental error, 1498.1, equals 2057.8 divided by the harmonic mean (1.37) of the subclasses within breed of sire and within dams.

* significant, P = < .05.

Table VII. Analysis of variance of six-month weights of calves out of nineteen Angus cows mated to Zebu, Africander and Zebu x Angus bulls.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total, using unweighted means	56	100801.6	
Between means of breed of sire	2	4118.4	2059.2
Between means of dams	18	49635.7	2758.7 *
Interactions	36	46253.5	1284.8
Experimental error 1/	50		1465.6
Total, using weights of individual calves	108	377189.6	
Between breed of sire, dam subclasses	56	163452.2	2918.4
Within breed of sire, dam subclasses	50	115725.4	2314.5
Between sires within breed of sire and dam subclasses	25	62506.4	2500.2
Within sires within breed of sire and dam subclasses	25	53220.0	2128.8

1/ The experimental error, 1465.6, equals 2314.5 divided by the harmonic mean (1.558) of the subclasses within breed of sire and within dams.

Significant, P = < .05

is indicated in Table I. The zebu bulls were of Kankrej breeding, often referred to as Guzerat (apparently coined from the Indian term Gujarat) in the United States, but there was a trace of Gir breeding in these bulls. These zebu breeds and other breeds of Indian cattle are described by Phillips.[5]

There was some variation in the average age of the Angus cows when bred to different types of bulls. However, the average ages in the groups mated to various types of bulls varied from 5.4 to 8.6 years, so that they could be considered as mature cows, on the average, when mated to each type of bull. Also, plotting of birth weights against age did not indicate any definite relationships. Hence, no corrections were made for age of cows.

The animals were divided into two groups for purposes of analysis. These are indicated above and include one group of nine cows mated to four types of bulls and another group of nineteen cows mated to three types of bulls. Analyses of variance were made using Yates' method of unweighted means as described by Snedesor.[10] Since the number of calves in each group was not large, weights of female calves were corrected to a male basis, using the average differences between the weights of the two sexes for calves from each type of bull as the correction factors.

Comparisons were also made between the mean weights of calves from the different types of bulls, using the pooled errors obtained from the analyses of variance in determining the significance of difference between the means.

The data on weights at birth and at six months were handled in a similar manner, except that at six months only three types of sires were considered in each group, owing to the lack of sufficient data at six months on calves from the offspring of zebu × Angus bulls in the group of nine cows.

Two sets of twin calves were born, but their weights were much lighter than most of the singles, and numbers were not large enough to make a correction factor reasonably accurate. Hence they were omitted in the analysis.

Data and Discussion

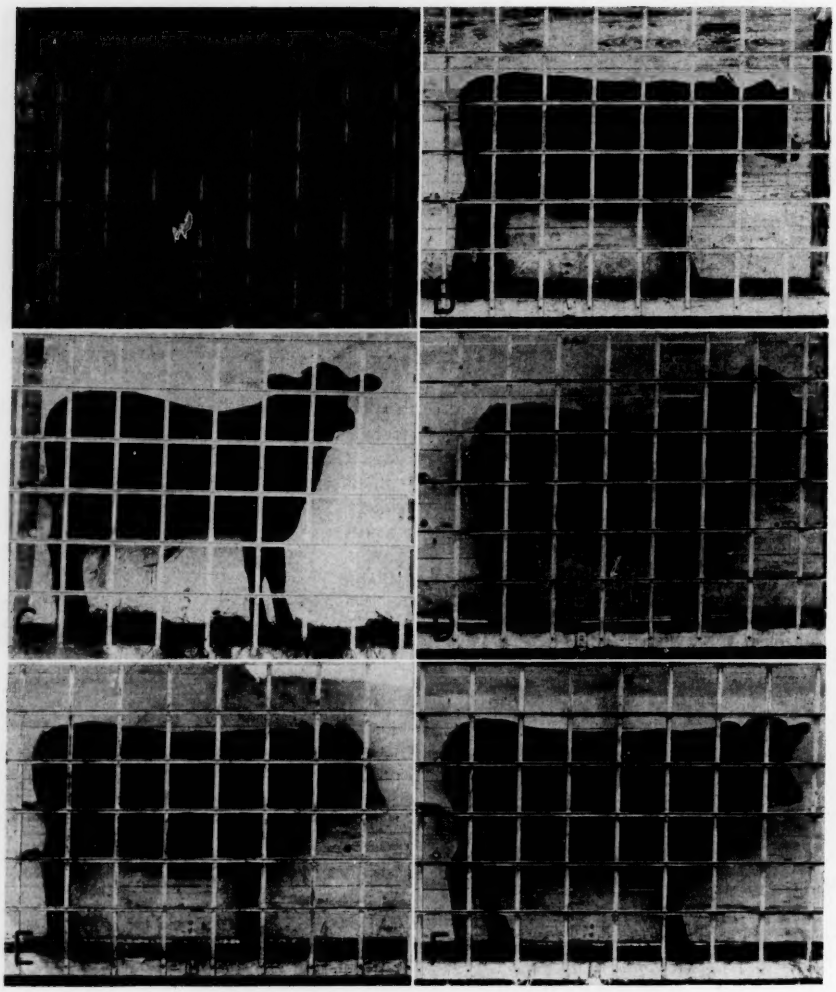
A total of 165 single calves were produced and used in this study. The number and average birth weight of calves from each bull, and from all bulls of each type of breeding, are shown in Table I. Data were available on only 141 of these at six months and the numbers and averages are also shown in Table I. The analyses presented below are based on portions of the data summarized in the table.

Birth Weights

The analyses of variance of birth weights, presented in tables II and III, show that breed of sire was significantly associated with the variation in birth weights of the calves. This source of variation was highly significant in the group where Angus bulls were used (Table II).

Variation between means of dams was significant in one group (Table III), but not in the other (Table II). On the whole, there was not a significant difference in the birth weights of calves from different bulls of the same breed, as is shown in the analyses of variance (Tables II and III), where the mean squares between sires within breed of sire and dam subclasses are not significant. The average birth weights of calves from all sires are shown in Table I, and inspection shows that the averages of bulls within breeds do not differ materially. The only case where there is a significant difference between offspring of sires of the same breeding is that between zebu × Angus bulls Nos. 7 and 51.

The average weights of calves from bulls of each type of breeding and differences between the averages of the various groups are shown in Tables IV and V. Calves from zebu bulls were significantly heavier at birth than those from bulls of any other breeding, while calves from Angus bulls were lighter than those of any other breeding. Average weights of calves from Africander



OFFSPRING FROM FIVE DIFFERENT SIRES

Figure 7

An Angus cow and five offspring resulting from polyallel crossing *A*—Aberdeen Angus cow. The five offspring were produced from matings with bulls of the following breeding: *B*—Aberdeen Angus. *C*—Zebu. *D*—Zebu × Angus. *E*—Africander. *F*—Africander × Angus. The dam was photographed at four years of age, and the other animals at about 18 months, except the one in *F*, which was photographed at two years of age.

and zebu × Angus bulls did not differ significantly from each other and were intermediate to those from Angus and zebu bulls.

Relatively few data are available on birth weights of beef cattle, and particularly on Angus and zebu cattle. Semple and Dvorachek[9] present data on 5, 7 and 9 Angus calves born in three successive years, which averaged 63, 69.7 and 66.8 pounds respectively. These calves were somewhat larger than those produced at Jeanerette, the latter averaging only 60.1 pounds (see Table I). No data are available on birth weights of zebu calves, but general observations indicate that they are quite small. Five zebu cows (Kankrej type) produced eleven calves at Jeanerette from matings with Angus bulls. Six females averaged 56.8, and five males averaged 56.4 pounds. Thus, these calves were much smaller than those produced in the reciprocal cross where Angus dams were used. One zebu calf was produced which weighed 57 pounds.

Weights at Six Months

Analyses of variance of weights at six months appear in Tables VI and VII. The variation associated with breed of sire was significant in the group where Angus bulls were used (Table VI), but not in the other group. This was due to the fact that the offspring of Angus bulls were considerably smaller at this stage than those from bulls of other breeding.

Variation between means of dams was significant in one group (Table VII) but not in the other (Table VI).

Variance between sires within breed of sire and dam subclasses was not significant in either group.

The average weights at six months of calves from different sires of the same breeding were reasonably consistent, as may be seen from the data presented in Table I, except for the offspring of the two Africander bulls, and two instances among the zebu × Angus bulls (Nos. 45 and 68) where the numbers are too small to give reliable average figures.

Average weights of calves from the two groups of cows studied, sired by bulls of different breeding, are presented in Tables VII and IX. Calves sired by Angus bulls were significantly lighter than those by zebu and Africander bulls. They were also much lighter than those sired by zebu × Angus bulls but a direct statistical comparison was not possible in this case. Differences between zebu, Africander and zebu × Angus calves were not significant, but the offspring of zebu bulls were heaviest from both groups of cows.

These findings indicate that hybrid calves carrying zebu or Africander blood are superior to Angus calves under conditions prevailing in the Gulf of Mexico Coastal Plains area, as measured by weight at six months of age. This is

Table VIII. Average six-month weights of calves from nine Angus cows mated to Angus, Zebu and Africander bulls, and differences between groups of calves.

Breeding of sire	Average 6-month weight (pounds)	Differences Angus	Differences Zebu
Angus	323.6	—	—
Zebu	382..	58.6 *	—
Africander	378.1	54.5 *	4.1

* Significant, P = < .05.

Table IX. Average six-month weights of calves from nineteen Angus cows mated to Zebu, Africander and Zebu x Angus bulls, and differences between groups of calves.

Breeding of sire	Average 6-month weight (pounds)	Differences Zebu	Differences Africander
Zebu	399.0	—	—
Africander	387.8	11.2	—
Zebu x Angus	378.2	20.8	9.6

Table X. Relation between weights of calves at birth and six months.

Breeding of sire	Number of calves	Coefficient of correlation	Regression equation for estimating 6-months wt. from birth weight 1/
Angus	15	0.60 *	E = 2.48B + 177.13
Zebu	48	.31 *	E = 1.44B + 386.80
Africander	39	.47 **	E = 2.91B + 147.84
Zebu x Angus	39	.39 **	E = 2.91B + 172.13

1/ In the equation, E = estimated weight in pounds at 6 months, B = birth weight in pounds.

* Significant, P = < .05. ** Highly significant, P = <.01

Table XI. Performance of zebu x Angus and Africander x Angus cows, as measured by birth and 6-month weights of their progeny, with offspring of Angus cows mated to Angus and zebu x Angus bulls, included for comparison.

Breeding of cows	Breeding of bulls	No. of offspring	Avg. birth weight (pounds)	Avg. weight at 6 months (pounds)
Zebu x Angus	Angus	42 1/	61.8	399.1
Angus	zebu x Angus	39	72.8	385.0
Angus	Angus	15	59.9	324.4
Africander x Angus	Africander x Angus	16	67.8	336.4

1/ Only 41 calves at 6 months.

in accord with results on the entire experiment as reported by Rhoad and Black.[7] The difference between calves sired by zebu and Africander bulls is not so clear cut but the averages are in favor of the zebu cattle.

Weight is of course not the only consideration in determining the value of a beef animal. Detailed carcass studies were not made on the animals used in this study. Black, Semple and Lush[1] report results of a study in which carcasses of Shorthorn and Hereford steers were compared with zebu × Shorthorn and zebu × Hereford steers after fattening in feed lots. Such results are not comparable with results that would be obtained when steers are marketed at weaning time, but they do indicate that the crossbreds produced reasonably satisfactory carcasses.

Broad generalizations cannot be made from results of a study such as this in which numbers are limited. These results indicate quite clearly, however, the way in which polyallel crossings can be applied to test the value of various types of crosses, so that variability among dams and environment can be brought under control. In this study the effects of yearly differences in environment were not controlled, but this could be done to a large extent in cases where breeding operations are specifically planned after a polyollel crossing design.

Relation between Weights at Birth and Six Months

A positive relationship between birth and subsequent weights has been demonstrated by several workers for sheep and swine. Literature on this point is reviewed by Phillips and Dawson.[6] Knapp, *et al*[3] report a positive correlation of .338, in a population of range cattle, between birth weight and daily gain from birth to weaning. When calculated on animals produced in the same year, the correlation was .316. Thus it appears that birth weights may be expected to give some indication of weight at a later age, such as at the age of six months used in the present study. The data were analyzed to determine if a positive relationship did exist within the various groups of offspring. The results are presented in Table X. All the coefficients of correlation are positive and are significant or highly significant. The relationships are far from perfect, but they do indicate that the larger calves at birth tend to be larger at six months.

Performance of Certain Crossbreds As Dams

The performance of calves up to six months, as indicated by weight, is the basis upon which calves of various types of breeding have been compared in previous sections of this paper. But if the females are to be utilized in a breeding program it is essential to know how they will perform as dams. A limited amount of data is available on the progeny of zebu × Angus and Africander × Angus cows, which give an indication of their uterine and milk-producing capacities.

Forty-two calves were produced by zebu × Angus cows, mated to Angus bulls. Average weight of these calves at birth and six months are shown in Table XI. Compared with the purebred Angus, these cows produced calves that were on the average 1.9 pounds heavier at birth than the purebred Angus calves (a non-signifianct difference) and 74.7 pounds heavier at six months (a highly significant difference).

Sixteen calves were produced by Africander × Angus cows, mated to Africander × Angus bulls. When compared with purebred Angus cows (see Table XI), the offspring of these crossbred cows weighed 7.9 pounds more than the Angus calves at birth (a significant difference), and 14.0 pounds more at six months (a non-significant difference).

The results with the two types of crossbred cows are not comparable owing to differences in the types of bulls to which they were mated, but they indicate that the Africander × Angus cows may have somewhat greater uter-

ine capacity as measured by birth weight of offspring, while the zebu × Angus cows appear to have a greater milk supply as measured by weight of offspring at six months. This indication concerning milk production agrees with field observations on the udder capacities of the two types.

A comparison of the progeny of the zebu × Angus cows mated to Angus bulls, with the progeny of the reciprocal cross is of considerable interest (see Table XI). Thirty-nine backcross calves out of Angus dams were 11.0 pounds heavier at birth than backcross calves out of zebu × Angus dams. Backcross calves out of zebu × Angus dams were only 1.9 pounds heavier than Angus calves, while the backcross calves from Angus dams were 12.9 pounds heavier than purebred Angus calves. These results indicate that the Angus cows have a greater potential uterine capacity than the zebu × Angus cows, thus allowing greater development of the crossbred fetus than is possible in the cows of zebu × Angus breeding. This appears logical in view of the material presented earlier which indicates that zebu cows produce small calves as a rule, and this tendency may be passed on to their offspring to some extent.

Backcross calves out of zebu × Angus cows did not differ significantly from those out of Angus cows in weight at six months, the difference being 14.1 pounds. Since the calves out of zebu × Angus cows were 11 pounds lighter at birth, they actually gained 25.1 pounds more up to six months of age, and this might be interpreted as indicating that zebu × Angus cows produce somewhat more milk than Angus cows. However, other factors may be involved. If one compares the calves produced in the zebu-Angus × Angus cross with Angus calves, it is found that the backcross calves were 60.6 pounds heavier at six months, a highly significant difference. Both backcross and Angus calves were reared on Angus cows, hence the difference would be attributable to breeding rather than to milk supply. This marked difference in breeding did not exist in the reciprocal crosses noted at the beginning of this paragraph, but it is entirely probable that the average genetic makeup of the two groups of calves was somewhat different. Thus both genetic differences and variation in milk supply might have been involved.

Summary

The results reported in this paper are based on data accumulated in cattle-breeding experiments at the Bureau of Animal Industry's Iberia Livestock Experiment Farm, Jeanerette, Louisiana. The analyses were designed to measure the relative merits of the offspring of Angus cows, mated to Angus, zebu, Africander and zebu × Angus bulls, and to demonstrate the possibilities of polyallel crossing in this and similar livestock-breeding experiments.

The breed of sire was found to be significantly associated with birth weight of calves when four types of bulls were mated to the same nine Angus cows. The calves ranked as follows in birth weight, by type of sire: zebu, Africander, zebu × Angus, and Angus. In a group of nineteen cows mated to three types of bulls, birth weight was also significantly associated with breed of sire and the calves ranked, by type of sire, in the following order: zebu, Africander and zebu × Angus.

The breed of sire was also found to be significantly associated with weight at six months, in an analysis in which Angus, Africander and zebu bulls were involved. This significant variation was largely due to the relatively small size of the Angus calves as compared with those from the other types of bulls. Calves sired by zebu bulls were only slightly heavier than those by Africander bulls. In a study involving offspring of zebu, Africander and zebu × Angus bulls, the calves ranked in that order but the variation among the averages for the three groups was not large enough to be significant.

Data on a limited number of zebu × Angus and Africander × Angus cows as dams indicated that offspring of zebu × Angus cows were somewhat lighter

at birth but heavier at six months than those from Africander × Angus cows, but the cows were not mated to comparable types of bulls.

The findings summarized above indicate that hybrid calves carrying zebu or Africander blood are superior to Angus calves under conditions prevailing in the Gulf of Mexico Coastal Plains area, as measured by weight at six months. The difference between calves sired by zebu and Africander bulls is not so clear cut, but the averages are in favor of the zebu crosses. The same is true of differences in performance of the two types of hybrids as dams.

A small positive correlation was found between weights at birth and six months in each of the groups studied.

The polyallel crossing technique reduces the variables in crossbreeding or hybridization studies by eliminating differences between dams or sires or both. In the present analyses only the breeding of the dams was constant, thus standardizing maternal factors that may have influenced results. The possibilities of critical analyses of results are indicated in this paper, and the method is adapted to wider application in animal breeding experimentation.

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Life Record

There is a great deal we don't know about human beings because accurate records of how people grow are so rare. For that reason a book with pages for "fill-ins" for many important data may serve a useful function. For that purpose "Our Son" and "Our Daughter, Through the Years," by Elizabeth A. Arnold, R.N. (Romaine Pearson Publishers, Incorporated, New York, New York), may have some value. It is a carefully bound blank book of 112 pages containing entries for birth certificate, weight and height records, date of first talking and walking and other characteristics such as eruption of juvenile and permanent teeth and a mass of relevant biological data plus much social information. There is even a two-page spread devoted to genealogy which links the parents, grandparents, and great grandparents in a rather interesting genealogical chart. There is no space for data regarding the characteristics of any of the ancestors, an omission which would seem unfortunate. A more complete survey of one's forefathers would surely have added to interest and such emphasis on physical and mental characteristics would give the volume considerable eugenic significance.

The book is intended to be presented by the physician to the parents of a new arrival and it may well encourage the more orderly and detailed collection of important data.—R. C.

✦

Wanted: A Human Geneticist

A large research institution needs a human geneticist competent to undertake studies of inheritance of physiological function patterns, growth patterns, etc., as a part of a serial study of children involving many disciplines. This is a unique opportunity for anyone who is interested and whose training is in this field. Large amounts of excellent data have been collected over the past fifteen years and are available for study along with currently collected material. Anyone interested please write Dr. L. W. Sontag, Fels Research Institute, Antioch College, Yellow Springs, Ohio.

A DACTYLOLYSIS MUTATION IN THE FOWL

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FIVE sibling chicks all having a sclerodermal condition of the feet were received by the diagnosis laboratory of the Veterinary Division of the University of Minnesota from a breeder of Record of Performance White Plymouth Rocks. The breeder complained that other defective progeny had been produced by a number of hens, and that some chicks with this condition had been appearing in the flock for as long as three years. Attempts to transmit the condition by contact from affected chicks to non-affected ones were of no avail, practically eliminating the possibility that an organism was the causative agent. It seemed probable under the circumstances that the scleroderma was due to some inheritable physiological disturbance. The results of subsequent breeding tests indicate that the abnormality has a genetic origin. During the tests, 451 progeny were secured of which 81 were defective.

Gross Description

Chicks that are affected appear quite normal until about one week of age. The first symptom of any unusual change is a hard glassy appearance of the sole of the foot accompanied by slight swelling (Figure 8*A*). A little later, usually one to two days, small fissures appear in the cornified epidermis of the sole. These cracks are always located at the joints of the toe. As the scleroderma progresses the fissures enlarge and are filled with bloody exudate (Figure 8*B*). In most cases the dermatitis is more or less confined to the ventral surface, but in those individuals which are affected in the extreme the epidermis of the entire foot becomes rather hardened and scaly.

Because of the lack of flexibility of the epidermis the mechanical action of the chick's movements seems to bring about the tearing and breaking of blood vessel walls and surrounding tissue. As a consequence the distal portion of the toe apparently suffers from lack of nourishment. It then atrophies, assuming a blackish mummified appearance. The proximal portion continues to grow and the distal portion sloughs off. The chick may, and quite frequently does, lose part of one or a portion of all of its toes so that only a stump remains (Figure 8*C*). There is no infection but merely a drying up of the affected area. This scleroderma of some individuals is so slight that they recover in a period of one or two weeks. In others the condition is severe and the cracks so enlarged that recovery in rare individuals may require as long as twelve weeks. The most seriously affected ones may have a very slight necrosis around the corners of the mouth and occasionally at the vent.

In most cases the chicks appear to be caused much pain when walking, so that they move as little as possible. As a result they neither eat nor drink adequately and so become somewhat emaciated and unthrifty. Weights taken on groups of sibs at seven days of age showed the affected and non-affected to be the same weight. Those having scleroderma and those which later developed it were as heavy and vigorous at that time as the non-affected. When weights were taken on the same two groups of chicks at fourteen days, a significant difference of 11.4 ± 2.82 grams was found in favor of the non-affected chicks. This difference is likely caused by the fact that the affected birds do not eat as readily as the non-affected ones. Some few defective birds survive the period of active necrosis after which there is a gradual healing. Survival of

affected individuals is difficult under the competition of practical rearing conditions. However, those that do so are apparently as healthy as normal chicks, reaching a satisfactory body weight. In the case of the few mature recovered females observed, they lay as well as the non-affected.

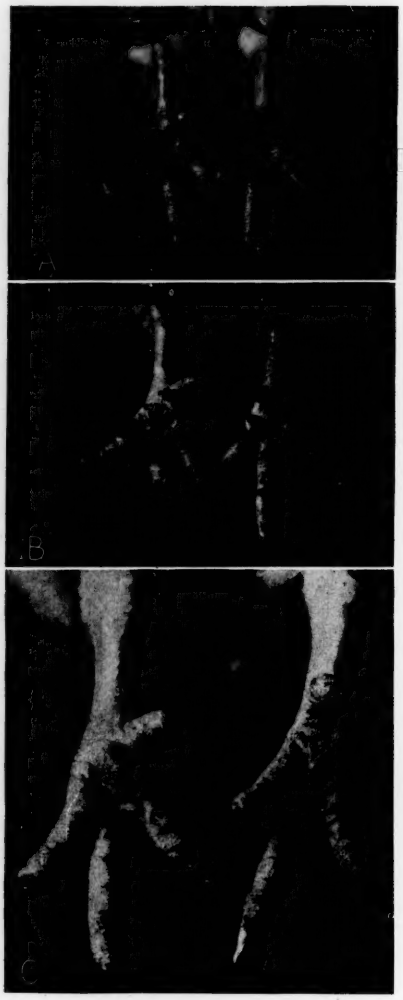
Histological Findings

Microscopic examination of longitudinal sections of defective toes from chicks two weeks of age shows some thickening of the cornified epidermal layers, which had been forcibly cracked open at the joints exposing the underlying derma. The reticular layers with accompanying blood vessels, nerves, and other tissues, are then exposed to abrasion. The fissures are filled with a non-differentiated scabby material infiltrated with blood cells. The bones appear to develop in a normal manner. The physiological interruption of the normal process may be that of diminished cutaneous lubricating secretion with a slight increase in the horny layers. This causes the drying and hardening of the dermal tissues.

Mode of Inheritance

The five sibling chicks sent in by the breeder were raised to maturity. Among them were two abnormal males, A4623 and A4624, one abnormal female A5164, and two normal females A635 and A1335. Male A4623 was mated to his three sisters and to four females of a non-related White Plymouth Rock strain. The recessive nature of the sclerodermal condition is indicated by the distribution of the progeny shown in Table I. The lack of sex linkage is demonstrated by the absence of affected individuals among the progeny from the non-related females. One would expect all female progeny to be abnormal from such a mating if the factor were a simple sex-linked one.

The following year an F_1 male, a son of a non-related hen, was mated to two abnormal females. The "backcross" ratio from this mating was 16 normal to 7 abnormal. This ratio does not depart



SCLERODERMA CYCLE
Figure 8

A—A chick one week of age in which the foot pad is beginning to harden. It has a glassy transulcent appearance, and fine cracks are just appearing on the ventral surface. *B*—A 17-day chick with an extreme case of scleroderma. The foot becomes somewhat flattened as the toes lack flexibility and the bird tends to walk on the heel of the foot. *C*—A pullet of 13 weeks showing recovery from an extreme case of scleroderma. The mummified distal phalanges of the fourth digit on the right foot and the second digit of the left foot remain attached.

significantly from equality. In addition the same F_1 male was mated to F_1 daughters of the non-related stock. The F_2 progeny of this mating produced 228 normal to 70 abnormal, a close approximation to the expected 3:1 ratio.

An analysis of chick mortality to fourteen days showed no significant difference between families of affected and non-affected chicks. Mortality is not a very satisfactory criterion, as all live chicks including weak and crippled ones were kept in the hope of detecting the condition. An examination of embryos dying shortly before hatching showed no visible morphological defects except for about .5% of a chondrodystrophic condition. This condition was not more prevalent among the embryos from any one hen than another. Hatchability varied considerably between hens, as much among those producing normal progeny as among those having abnormal ones. Apparently the factor does not affect development of the embryo, but manifests itself only for a certain time after hatching.

Discussion

To the author's knowledge the condition here reported had not previously been described. There are, however, other pathological conditions which result in loss of the toes. Van Heelsbergen[1] cited a chronic case of ergot poisoning in which there is a gangrenous mummification of the comb, wattles and toes. The dry gangrenous condition of the toes is caused by constriction of the small blood vessels, which seems to act in a more or less localized center on the toe, resulting in an even constriction around the toe, leaving a dead peripheral portion. Newsome and Feldman[3] have described a vesicular dermatitis of young chicks which is characterized by the formation of blisters on the toes, the foot becoming swollen and rigid. In severe cases part of a toe or even an entire toe is lost. The dermatitis appeared in those chicks which ranged over unbroken prairie sod and was called "sod disease."

A recent report of the National Research Council[2] describes a necrotic dermatitis of the chick's foot caused by a deficiency of panthothenic acid in the ration. This dermatitis is similar in some respects to the scleroderma here reported, except that in pantothenic acid deficiency there is first a granulation of the eyelids and formation of crusty scabs at the corners of the mouth and around the vent. Chicks which receive inadequate amounts of biotin also manifest a foot dermatitis. The foot lesions became severe only when the deficiencies are extreme but the mandibular lesions and eyelid granulations may be quite severe. Mandibular or vent lesions on the chicks having the sclerodermal condition are practically non-existant except for the most extremely affected individuals.

There is the possibility the chicks with the sclerodermal condition inherently are unable to assimilate biotin, pantothenic acid or some other essential food element from the ration. During the three different years that chicks with the pathologic condition were raised they received the same chick starter mash fed to all chicks at the station. Several thousand chicks of various breeds fed the same ration gave no evidence of any of the vitamin B-complex deficiencies.

From the viewpoint of developmental genetics the greatest interest is found in the limitations of expression during development more than in the mode of inheritance. There is a specific interval during the life of the chick when the normal functional processes of the derma on the foot are interrupted. Insofar as can be determined, the gene responsible for the scleroderma has its first noticeable expression at from seven to fourteen days after hatching. The individual thus affected goes through a period of active dermatosclerosis, the length varying somewhat, depending upon the severity of the condition. Later the foot begins to heal and the birds recover if environmental conditions are favorable for their well-being.

Perhaps the malfunction has its origin at a more primary source, affecting the epidermis of the foot only secondarily. If such were the case it might be ex-

pected that other body surfaces would be affected which to all appearances does not happen. The fact that no other manifestation of the gene during embryonic development is shown by gross morphological abnormalities or by excessive embryonic mortality does not exclude the possibility of its occurrence.

The practical significance of such a mutation may be realized in the fact that a Record of Performance (R. O. P.) bird is a prolific disseminator of genes. Such individuals are of proven performance and from them as many progeny are secured as possible. The abnormality was noted in the stock for at least three years before any concern was manifested over its occurrence. Only during the fourth year when it appeared among the offspring of a number of the better R. O. P. hens, was it cause for concern. How widely the mutation had been disseminated through the flock is not known. The fact that it was detected in the progeny of as many as half a dozen hens out of a pen mating of about twenty hens mated to the particular R. O. P. sire of the chicks sent to University Farm indicates that it may be quite widespread. The matings were not entirely random, and it remains possible that certain families were kept to the exclusion of others. The unfortunate choice of the above heterozygous sire gives assurance that about fifty per cent of his progeny would carry the gene. The homozygous individuals are relatively easy to eliminate as breeders, even those that might possibly survive the growing period. The elimination of all the gene-carrying progeny and their parents would represent a considerable loss to a breeder. To be certain that all carriers in the group had been identified and disposed of would require special matings to recessive homozygotes, an expensive and time-consuming operation.

Summary and Conclusions

1. A mutation having as its expression a sclerodermic condition of the feet appeared in a Record of Performance flock of White Plymouth Rocks. The mutation proved to be a simple Mendelian recessive.

2. The character is semilethal, due in part to the difficulty of coping with environment, and possibly in part to adverse action on the chick of the condition itself. Under practical conditions of competition with normal chicks it is almost entirely lethal.

3. The character has a definite time expression in the life of the chick, appearing at about one week of age, when there is a period of active sclerosis followed by recovery and healing. The adults appear normal except for missing digits.

4. Insofar as could be determined there are no other expressions manifested by the gene.

5. A mutation such as this adds considerably to the labors of a breeder in his selection efforts.

Table I. The progeny of abnormal male A4625 mated to his three sisters and to four non-related females

Dam	Progeny	
	Normal	Abnormal
Sister A5164 (abnormal)	0	1
Sister A1535 (normal)	15	3
Sister A625 (normal)	12	0
Non-related four females (normal)	100	0

Table II. The progeny of a normal male from one of the non-related hens (Table I), mated to two abnormal females and to 10 normal hybrid females (Table I).

Dam	Progeny		
	Normal	Abnormal	P^2
Abnormal females	13	7	3.53
Normal females	880	70	.36

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Organic Chemistry

ORGANIC compounds at present known and characterized represent an impressive collection numbering several hundred thousand. The really staggering possibilities may be illustrated by some figures given by Henze and Blair

(*Jour. Am. Chem. Soc.* 53: 3042 and 3077, 1931). In the group of saturated hydrocarbons having twenty carbon atoms there are possible 366,319 isomers, while the formula $C_{40}H_{82}$ fits 62,491,178,805,831 isomeric forms. Substitution of one functional group for one hydrogen atom in the twenty carbon atom series results in approximately a sixteen-fold increase in the number of compounds. That is, there are 5,622,109 isomeric alcohols represented by the formula $C_{20}H_{41}OH$ and a like number of carboxylic acids with the formula $C_{20}H_{41}COOH$. Formation of simple esters between these alcohols and acids would result in about 3×10^{13} compounds.

Without considering further variables such as multiple substitution, unsaturation, ring formation, etc., it becomes obvious that a book entitled *Organic Chemistry* should go further than the conventional classification of compounds on the basis of certain functional groups substituted on a hydrocarbon skeleton and should consider the effect of the skeleton on the reactivity of the functional groups. The book by Fieser and Fieser* does so in a discussion of the alkyl halides and further in the same vein, the authors have adopted the excellent practice of giving yields whenever possible, along with equations for synthetic reactions. Such a practice should do much to alleviate the dismay of the uninitiated on finding that compounds often do not behave according to "text-book reactions."

In view of the decided leaning toward the biological side of organic chemistry, it is indeed surprising that the Fiesers' presentation of organic chemistry is completely deficient in an organized discussion of heterocyclic compounds. Nucleic acids and certain related compounds are not mentioned at all.

Other sections of special biological interest are exceptionally good. The chapter on "Microbiological Processes" presents a stimulating discussion of species, strains and environmental influences on the synthetic abilities of many microorganisms; a presentation that may be profitably correlated with similar considerations from the genetic point of view as recently reviewed by Beadle (*Physiol. Rev.,* In Press, and *Chem. Rev.,* In Press). In these review articles it is considered that the specific synthetic abilities of an organism depend on the presence of certain enzymes which owe their existence and specificity to corresponding heritable units, the genes. Furthermore, evidence supports the belief that a one-to-one ratio exists between genes and enzymes. Thus, the introduction of genetic principles and tools in studies of biosynthesis and into development of commercial processes for producing pure chemicals by means of synthetic abilities of living organisms should be and is proving a profitable development.

Organic Chemistry by Fieser and Fieser is published in two editions, one being an abridged form. It is the opinion of the reviewer that the special chapters in the long edition add tremendously to the value of the book. These modernized essays on petroleum, rubber, proteins, microbiological processes, carbohydrates in biological processes, metabolism of fats, proteins and amino acids, synthetic fibers, plastics, isoprenoid compounds, accessory dietary factors and chemotherapy in combination with a good general presentation of the principles of organic chemistry serve to recommend the book as a valuable addition to a biological library.

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*A review of *Organic Chemistry* by Louis F. Fieser and Mary Fieser. D. C. Heath and Co., Boston (1944).

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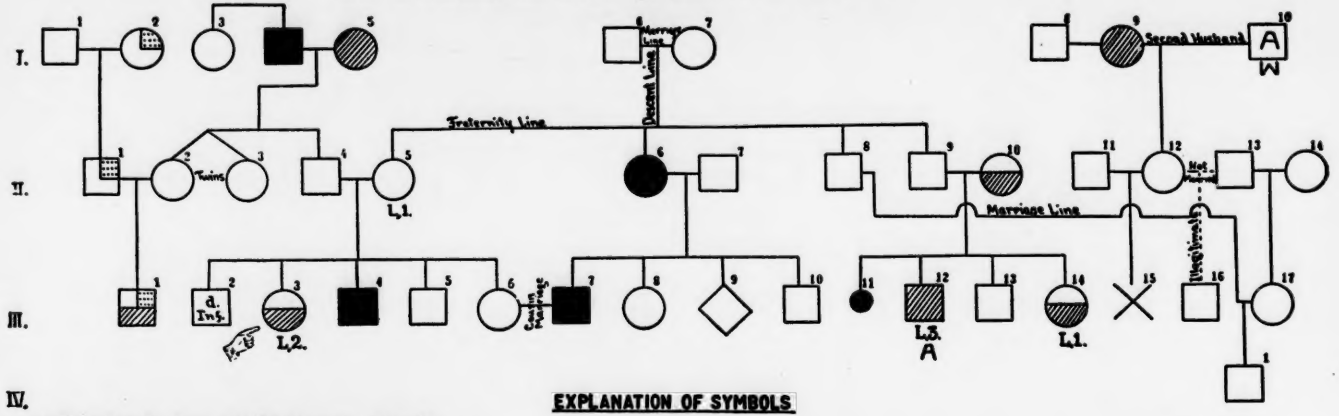

EXPLANATION OF SYMBOLS

(a) **Standard for all Pedigree Charts:**

□=Male; ○=Female; ◇=Sex unknown; ●=Still-birth or Miscarriage; X=Children — number and sex unknown; ○○=Twins; d. Inf.=Died in Infancy; ☞ Points to the Propositus or central figure in the pedigree.

□—○=Parents.

□○□○○=Children.

Roman figures to the left indicate generations; Arabic figures locate individuals, (thus III, 7 is the young man in the third generation who married his cousin).

The following letters, placed in or around the individual's pedigree symbol, are standard for certain traits: A, alcoholic; B, blind; D, deaf; E, epileptic, F, feebleminded, I, insane, M, migraineous; N, normal in reference to traits under consideration; Ne, neurotic; P, paralytic; Sx, sexually immoral; S, syphilelic; T, tuberculous; W, wanderer.

(b) **Especially devised or selected for this particular pedigree-chart:**

■ ● = Successful leaders in politics. ◱ ◔ = Extra thumb on right hand. L.1. = Highly successful author. L.3. = Little or no ability in literary efforts. ▨ ▨ = Superior in vocal music. ▨ ▨ = Medium attainment in vocal music.

To fit the particular family and traits (whether physical, mental or temperamental; good or bad) under consideration, invent special symbols, or select special letters (in addition to those standardized under (a) above) to be placed within or near the particular individual's pedigree symbol, to indicate particular traits and their degree of development.

Prepared by the International Commission of Eugenics. See *Journal of Heredity* for August 1926. Additional copies may be obtained from A.G.A.